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REPORT

A metric terrain coder

J.A. Fox, B.Sc.(Eng.)
P.L. Marsden, B.Eng.(Electronics)

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

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Summary

The Report describes equipment used to prepare the main input data for predicting the service area of v.h.f. and u.h.f. transmitting stations by computer. Information on contour height and other topographical features as a function of bearing and distance from the transmitter, obtained from Ordnance Survey metric maps, is coded and punched onto a paper tape. This is used in conjunction with a prediction computer program, which produces an output of field-strength against distance for a particular set of transmitting conditions, to form the basis of a coverage map.

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C P Sandbank

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

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Fig. 1 - Photograph of complete equipment in operation

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1. Introduction

The Metric Terrain Coder was designed to be used with the new metric Ordnance Survey maps in prediction work although the old imperial maps can also be used. The main function is to permit coding of the terrain height along radials from a transmitter but other features on the map which affect the calculations can be entered into the data from the Cursor Unit buttons, e.g. water, trees.

To provide for the range of contour intervals required for metric and Imperial map scales, the coder is provided with a wide range of height intervals which can be selected by a switch, unlike the original terrain coder.[1] This enables prediction work to be done for most countries.

Distance scaling is simply done by entering the correct map scale factor, e.g. 1:25,000 in the data at the start of the particular prediction run.

The coder is interfaced with an Olivetti TE 318 Teletype which provides a punched-tape output together with a printed record; a photograph of the entire equipment is shown in Fig. 1. The printed output enables mistakes to be seen and corrected before the data is entered into the computer for field strength calculations. The keyboard allows relevant data to be entered, e.g. transmitting aerial height and gain, before the coding process.

When the metric coder was first designed it used TTL logic which required a large supply current. As the high speed capability of TTL was not required, is was decided to redesign using CosMos logic which is slower, but needs far less supply current, even with the additional facilities. To assist the explanations contained in the following sections Fig. 2 provides a block schematic diagram of the complete coder. The more detailed circuit diagram of the various sub-units are given in BBC drawings as follows: R201389/A1; R201350/A3; R53884/A1; R53921/A3; R53888/A1; R53880/A2; R77244/A3; R201320/A1; R201319/A2.

2. Height measurement

The height counter is a four decade up-down counter and operates in the ripple-through configuration with a range of 0-9999, zero corresponding to Ordnance Datum. The Type CD4029A counter integrated circuits used have no re-set input, so zeroing is done by pre-setting to zero. The counter operates in one of the following three modes.

(i) Fast run

This gives a high speed clock (about 100 pps) to the counter to allow quick approximate setting of the starting height.

(ii) Slow run

This has a clock rate of 2 pps allowing the exact starting height to be set.

(iii) Interval or step

This gives a pre-set number of fast clocks to the counter, the number corresponding to the height contour interval of the map in use. These are units of 1, 2, 5, 10, 20, 25 and 50 expressed in either metres or feet.

The interval function is implemented by feeding the fast clock into an auxiliary two decade counter and then taking the appropriate output, via a short delay (about 2 mS) consisting of two monostables, to the start/stop bistable and also to the auxiliary counter reset. The delay is to prevent miscounting which would occur if the up/down command coincides with the clock pulse.

As frequency stability is not important, the clock generators are simple gated astables. In the FAST and SLOW run modes, when the UP or DOWN button is pressed the start/stop bistable is set to start and the up/down bistable is set as appropriate. The fast and slow clocks and interpolate clock are combined into the height counter by an OR gate.

A further facility when in the interval mode is the interpolate function which enables 'spot heights' to be entered into the data, e.g. tops of hills, trigonometic points. These heights usually do not coincide with contour lines and so a method of incrementing the height counter by

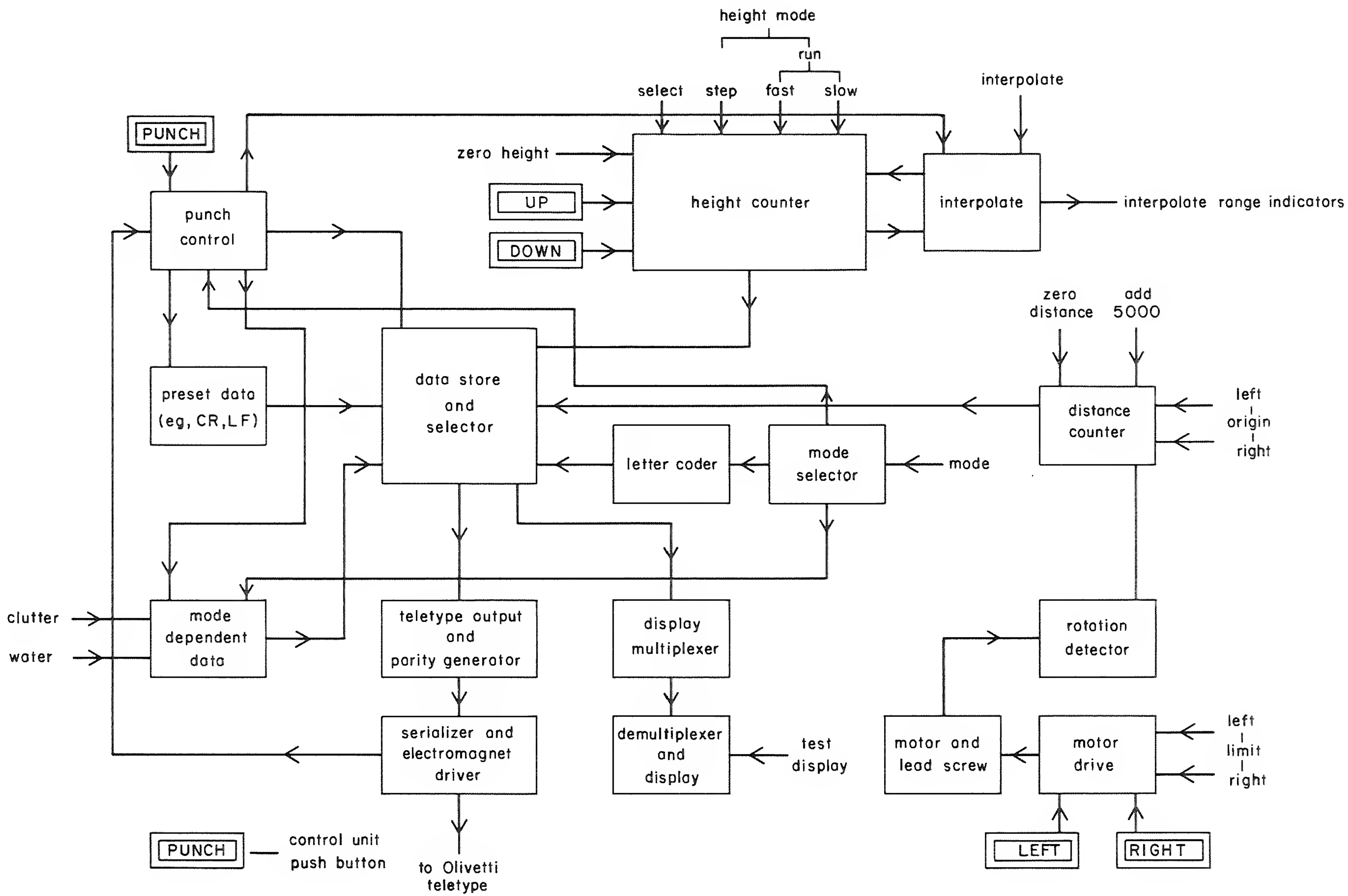

Fig. 2 - Metric Terrain Coder block schematic diagram

less than the step interval is required. This is implemented by having an interpolate clock and counter in the cursor unit controlled by a set of ten buttons. When an interpolate button is pressed an up signal is sent to the main height counter, the appropriate output from the interpolate counter is selected and the interpolate clock is started. When the counter reaches the correct count, the selected output stops the clock. After the data has been punched out a signal from the punch control repeats the process except that a down signal is sent to the height counter and so resets the counter to the previous figure. The interpolate input can also be cancelled by pressing the zero interpolate button. The interpolate buttons are linked to the height interval such that steps of 1 and 2 have no interpolate facility; 5 has 1 to 4; 10 has 1 to 9; 20 and 25 have 5 to 20 in steps of 5 and 50 has 5 to 45. These ranges are indicated on the cursor unit by light-emitting diodes (l.e.d.s.).

3. Distance measurement

The map is traversed by a cursor driven from a precision lead-screw with a total mechanical range of 500 mm. The lead screw is rotated by a four-phase stepping-motor of 200 steps per revolution and a maximum speed of 450 steps per second. A stepping motor has several advantages:—

(i) Wide speed range with high torque at low speed allowing accurate positioning of the cursor.

(ii) At zero speed there is magnetic braking thus preventing overshoot.

(iii) Easily reversible by changing the phase of the driving waveforms.

To achieve 450 steps per second, the motor has to be brought up to speed slowly and this is done using a voltage controlled oscillator, the control voltage being derived from a time constant of approximately nine seconds, with the first two seconds being used to give a fairly linear ramp. The initial slow speed of the motor run-up characteristic enables the cursor to be positioned accurately. Total traverse time of the cursor over the 500 mm is approximately four minutes but, as it is possible to disengage the cursor from the lead screw and return it manually to the start, this length of time is not normally inconvenient. At each end of the cursor travel is a micro-switch which automatically stops the motor and also determines the direction of the distance counter, e.g. of the cursor is moved to the left end-stop, the counter counts up when the cursor moves to the right.

Attached to one end of the lead screw is a toothed disc which interrupts two l.e.d. — phototransistor pairs to give two pulse trains in quadrature. These are processed to give a direction signal and clocking pulses which are fed to a second four decade up/down counter. Each clock pulse corresponds to a 1/10 mm movement of the cursor giving a count of 5000 for a complete cursor travel. The counter can be preset to 5000 to extend the range of a radial to 1000 mm. Zeroing the counter is achieved to disengaging the cursor from the lead screw to activate a microswitch.

4. Mode selection, display and data output

4.1. Operational description

To do a complete profile for a particular radial, the machine has to traverse the selected radial several times extracting different information from the map each time. The operator selects the desired mode on the cursor unit front panel, which in turn provides outputs for decoding from a decade counter set to divide by six. The chosen mode is then indicated by one of a set of six l.e.d.s. The selection permits any one of the following operations to proceed:—

(i) K or keyboard

This mode enables transmitter and aerial data to be typed in on the teleprinter keyboard.

(ii) R or range

The data entered in this mode determines the areas of interest along the radial, for example, if two villages lie on the radial the detailed calculations are concentrated on just the village areas.

(iii) P or points

In this mode various points of interest are selected which are outside the areas previously selected. These points may be receiving sites suitable for further relays or areas of proposed housing development.

(iv) H or height

This mode enables height information to be

recorded. Each time a contour is reached the relevant height and distance from the transmitter is recorded when entered by the operator. A 'water' code can also be inserted into the output data to indicate that the radial passes through an area of water such as a lake.

(v) C or clutter (density)

Allows areas of obstructions, i.e. trees or buildings, to be recorded by inserting a density figure into the output data. The figures are inserted by gating the appropriate bits into the data multiplexer. Four ascending levels of density are available for selection and a check indication of those as provided by l.e.d.s.

(vi) E or end

When punched, signifies the end of a particular radial. An extra E punched from the keyboard signifies the end of the complete prediction, that is, a group of radials from one transmitter site.

The number display and teleprinter data output each have a different format depending on the mode of the machine; the differences in the printed data output enable the operator to recognize the mode at a glance, which is useful when editing the data, especially on long radials. Fig. 3 is an example of the output format which displays the data listing that would follow the transmitter and aerial information.

To enable a check on the data being entered, the cursor unit has three sets of four-digit displays. Two of the sets are for displaying distance showing the starting and running distances of each range or clutter group. However, in the P (points) or H (height) mode only one distance display is used. The third display is for the height figure.

To output the data onto the combined teletype/punched tape machine, the operator presses the punch button. In the range and clutter modes the first operation of the punch button transfers into a store the starting distance and the second punch operation outputs both distances. While in the P and H mode, just one operation of the punch button is necessary to output the data.

4.2. Circuit description

To run the teleprinter together with its integral paper tape punch, the eight-bit parallel output

```
14103   HELSTON PREDICTION 14/9/79
8.5
R
00.05      02.30
03.87      07.40
P
02.64
02.90
03.19
H
00.00      0220
00.73      0200
01.86      0175
02.73      0150
03.45      0125
03.85      0800
04.43      0075
05.42      0050
05.61     -0025
05.94     -0025
06.16      0050
06.47      0075
07.09      0100
07.40      0100
07.63      0100
07.93      0125
C
01.52 01 02.42
02.83 02 03.14
05.33 01 06.99
07.00 02 07.01
07.01 01 07.35
E
E
```

Fig. 3 - Teleprinter output format

must be changed into serial form. This is done by an eleven bit parallel-in/serial-out shift register. The three extra bits are used to start and stop the teleprinter and are clocked out at a rate to give a word time of 100 ms. To ensure that these peripherals operate at full speed it is necessary to run the receiver electromagnet from a 60 volts supply with a series resistor to limit the current to approximately 40 mA. This reduces the effect of the inductance of the coils and allows the full magnetizing current to be reached in the minimum time. It is also advantageous to use 'double current' operation (i.e. to reverse the applied voltage to the coils) to move the receiver contact rather than allowing it to return to the rest position under spring tension, thereby reducing the transit time of the contact. An output from the serializer disables the punch button to prevent its

use during a data output sequence which could possibly result in false data being punched.

Data multiplexing for the teleprinter and punch is achieved using an array of 12 eight-channel multiplexers. It is necessary to add extra bits to the end of the b.c.d. code to convert it to teletype code. Also generated are spaces, decimal points, carriage return and line feed codes which enable a readable printed output to be made. In the clutter mode two of the spaces are taken up by a clutter code, and in the height mode a water code may be inserted in a space. Switching these various inputs to the multiplexer is done with AND-OR select gates. The six outputs of the multiplexers go to seven AND-OR select gates (seventh input is ground) with the seven other inputs coming from a letter coder. These gates normally pass height and distance data but when the mode select is operated, the letter code output is automatically selected. The coder is a clocked diode matrix which gives the appropriate letter, (e.g. H for height) followed by carriage return and line feed. From these seven bits an eighth parity bit is generated by exclusive OR gates.

As the cursor unit and display is remote from the height and distance counters located in the teleprinter case, it was necessary to multiplex the 12 digits so as to reduce the number of interconnecting wires from 50 to 10 and keep the cable size down. The multiplex frequency is approximately 25 kHz and gives an on-to-off ratio of 1:16 requiring a peak segment current of 150 mA to give good display brightness in high lighting levels.

5. Conclusion

The Metric Terrain Coder has proved successful in providing data for many domestic and continental predictions. Some modifications to the original design were made to reduce operator error and so increase speed of obtaining a result.

With the prospect of a large number of small relay stations to be planned, those will be a proportion for which predicted data is desirable before or in place of field measurements. The terrain coder is a useful tool in providing prediction information, in the form of field-strength calculations along certain chosen radials, from which service area maps can be drawn. Furthermore, changes in the computer program have allowed profiles far larger than originally specified to be done, up to 100 kms depending on map scale, which is particularly useful when undertaking predictions for foreign broadcasting authorities on a consultancy basis.

6. References

1. SUSANS, D.E. A digital terrain coder for transferring map data onto paper tape. BBC Research Department Report No. RA-22, Serial No. 1968/28.

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